Human Error Assessment in the Accident Causations Experienced among Vehicle Drivers in the Philippines

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Abstract

According to statistics, thousands of people are killed and injured on roads. The Philippines is ranked 116th in the world out of 183 countries for having the highest death rate caused by road traffic accidents. This kind of issue has to be discussed for this involves the lives of people. The researchers have conducted their preliminary study by researching through existing studies that discuss the reasons for the problems to occur. The researchers have identified the main cause of the problem to occur among drivers through literature reviews which also happens to be the possible primary cause of road accidents in Metro Manila is driver recognition error, which includes driver inattention, internal and external distractions, and inadequate surveillance. But to further identify the main causes or factors for these problems to occur, the researchers conducted a survey through the distribution of questionnaires. The respondents of the survey are licensed drivers in Metro Manila. At the end of the study, the researchers have used several tools to identify the factors that are significant for the problems to occur. Anxiety, motivation, and sleep were the factors that affect attention level among drivers. The researchers have recommended designing a predictive model which will help prevent or reduce road accidents in Metro Manila. With that in mind, together with the results of the study, the researchers are compelled to make recommendations in order to improve driving situations here in Metro Manila.

Keywords

Cognitive Ergonomics, Attention, Road Accidents, Driver Error, Recognition Error

1. Introduction

Road accidents happen on a daily basis and road safety will always be an important issue to be addressed since human well-being is at stake when road safety is not carefully evaluated and considered. Meticulous assessment of drivers must be done in order to ensure that public roads are as safe as possible for everyone. Moreover, a great responsibility lies in the hands of the people who operate motor vehicles in public roads as the cognitive state (attention) of the driver has been recognized as an important aspect in improving safety in vehicles since errors are by-products of the human cognitive function (Sena, 2013).

Based on the World Health Organization report of the year 2017, deaths caused by road traffic accidents in the Philippines reached 10,767, translating to an age-adjusted death rate of 11.82 per 100,000 persons and ranking the Philippines one hundred sixteenth (116th) out of one hundred eighty-three (183) countries globally. The driving task requires the full attention of the driver, and a significant percentage of road accidents happen because of driver error. The Metro Manila Accident Recording and Analysis System (MMARAS) reported in the year 2016 that driver error constitutes ninety-eight percent (98%) of the total number of accidents attributed to human error under road traffic accident causations. However, driver error on its own is still a very broad concept, which is why the National Highway and Traffic Safety Administration of the United States further classified driver error as recognition errors,

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decision errors, performance errors, and non-performance errors in their 2015 report. Recognition errors constitute forty-one percent (41%) of driver-related critical reasons for road accidents.

This study aims to identify and analyze the statistically significant variables that contribute to the driver recognition errors among private vehicle drivers in Metro Manila, Philippines in order to recommend ergonomic solutions that will improve driver's stimuli recognition which may lead to decreased road accidents. The study will limit its focus to assessing the driver's cognitive ability while performing the driving task, specifically among drivers in Metro Manila, Philippines. Actions that may be carried out by the agencies concerned with driver qualification regarding the scores that will be obtained from the subjects are not included in this study.

2. Literature Review

Road safety can only be achieved by reducing the number of accidents on the road. In order to achieve this, government agencies concerned with road safety must assess the different factors that are involved in road accidents, and since the cognitive state of the driver has been recognized as an important aspect in improving safety in vehicles (Sena, 2013), the factors that have an influence in the driver's cognitive state must be identified.

Driving is a complex man-machine system, which means that the relative information present in a rapidly changing traffic environment must be clearly defined. This ability to conceptualize the current situation and execute the right decision to be able to drive smoothly and avoid traffic accidents is called situation awareness (Endsley, 1997). Driver attention is influenced by several factors (i.e. selecting the right action at the right moment in order to arrive at the destination while maintaining safety margins) results to difficulties experienced by these people (Engstrom, 2011). According to Rong, Zhang, and Zhao (2013), alcohol influences drivers by making them impulsive, sensation-seeking, and adventurous, while at the same time impairing the ability of judgment, recognition, reaction, and operation. Anxiety, stress, mood, and fatigue affect the driver in the same way. The studies conducted by Clapp et al (2014) and Matthews et al (1998) state that driving anxiety and stress is closely related to risky and aggressive driving. This behaviour makes the driver predisposed to experience physiologic arousal in response to the stressful driving situation (Deffenbacher et al, 2014) which, in turn, triggers a variety of effective and cognitive characteristics that include impaired social information processing and poor estimation of controllability, as stated in the study conducted by Kunimatsu and Marsee (2012). As a result, vigilant attention and reaction time is reduced (Mollicone et al, 2018; Lau, 2016). However, the findings of Sherwood (1995) suggest otherwise. Sherwood's findings state that nicotine tends to enhance a driver's cognitive and psychomotor functions, which results in improved driving performance.

Moreover, the duration of the driving task shows little to no impairment, as observed in drivers introduced to a relatively short driving task, but when the duration of the driving task is increased, even when low attentional demand is required and only a few stimuli are introduced, drivers are not able to maintain optimal performance levels (Perrier et al, 2014). The impairment observed because of task duration is similar to the effect of workload on drivers. According to Duncan et al (1987), errors arise due to the incompatibility between the characteristics of the human and task demands, and a driver's professional experience or inexperience helps in the reasoning behind decisions made while driving. This is supported by the findings of Merat, Antilla, and Luoma (2005) and Sharifah, Lizati, and Nor Fadilah (2016). Both studies suggest that individual factors, such as age and gender, contribute to errors committed by drivers. When it comes to age, older drivers tend to miss a greater number of driving stimuli mainly because of limited cognitive resources as a result of aging. On the other hand, gender becomes a factor as male drivers get involved in road accidents more frequently which can be attributed to the difference in behavior between genders. According to Yagil (1998), the effect of motivation and gender to driving performance is related as male drivers express lower motivation when it comes to complying with traffic rules.

Based on the literature, research studies done in the Philippines only investigated the effects of selected factors to driver attention which leads to driver error. However, these research studies provided a broad point of view. With this, this paper considered a more specific area of driver error, particularly recognition errors experienced by private

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vehicle drivers. The figure shown below shows the framework formed from by the researchers which are based on an extensive literature review and expert judgment of experts.

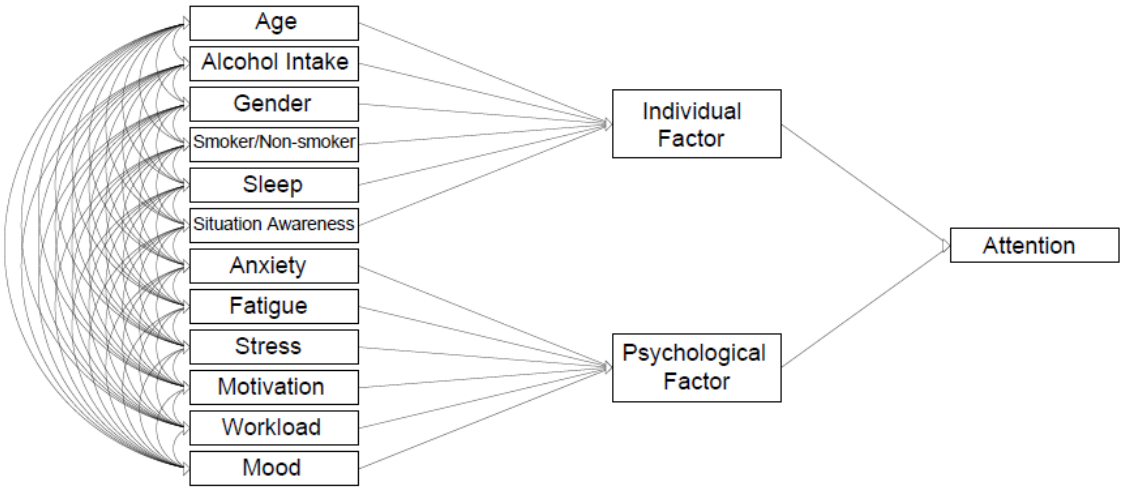

Figure 1. Conceptual Framework

A. Individual Factors

Individual factors are factors that pertain to the personal information associated with private vehicle drivers. It includes the age of the driver, the alcohol level of the driver's preferred alcoholic beverage, smoking habits, amount of sleep, and situation awareness level that may affect the driving performance of the driver. The variables included in this set are significant as these factors have a direct effect on a driver's attention level that leads to recognition errors.

B. Psychological Factors

Psychological factors are factors related to how a driver processes information while performing the driving task. These factors are associated with the driver's personality and encompass the driver's anxiety level, fatigue level, stress level, motivation level, the effect of the driving workload to driving performance, and the driver's mood. The variables included in this set are significant since these factors affect a driver's stimuli recognition and perception.

C. Dependent Variable

The dependent variable in this research study is driver attention level because recognition errors happen as a result of driver inattention (NHTSA, 2015; MMARAS, 2016).

3. Research Design and Methodology

3.1 Sampling Frame

The subjects covered by the study are private motor vehicle drivers who operate within Metro Manila. A sample size was determined from which the data were obtained to represent the whole private motor vehicle driver population of the region. Cochran's (1977) formula was used to determine the 384 samples needed since a desired level of precision, desired confidence level, and estimate of variance was identified. The computation below shows how the sample size was determined.

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$$No = \frac{(t)^2\,(p)(q)}{(d)^2} \qquad (1)$$

where:

t = selected alpha level value for two-tailed test

p, q = estimate of variance = 0.5

d = estimated acceptable margin of error for categorical data = 0.05

$$No = \frac{(1.96)^2\,(0.5)(0.5)}{(0.05)^2} = 384 \text{ samples}$$

Private vehicle drivers who are prone to recognition errors consist mostly of males and most of the respondents belong to the 18-24-year-old age group. Table 1 shows the demographics of the sample size. Eighty-seven percent (87%) of private vehicle drivers who operate in Metro Manila are male and fifty-seven percent (57%) fall under the 18-24 years old age bracket. When it comes to smoking habits, thirty-two percent (32%) of Metro Manila private vehicle drivers are smokers while sixty-eight percent (68%) are non-smokers.

Table 1. Descriptive Analysis of Private Vehicle Drivers' Demographics

DEMOGRAPHICS	Frequency	Percentage
Gender		
Male	283	87%
Female	43	13%
Age		
18-24	185	57%
25-30	47	14%
31-36	32	10%
37-42	18	6%
43-48	18	6%
49-54	15	5%
55-60	11	3%
Smoker/Non-Smoker		
Smoker	103	32%
Non-smoker	223	68%

3.2 Data Collection

In the collection data, the researchers utilized a descriptive-normative survey, which gathers the normal or typical response of the samples in performing the driving task with the use of questionnaires. Secondly, the researchers checked the normality of the data gathered to check its validity of being bias-free. This was followed by a correlational analysis and multiple regression using the Minitab 17 statistical software. After the statistically significant variables were determined, ergonomic solutions will be recommended to improve driver's stimuli recognition to decrease the risk of road accidents among the private vehicle drivers in the Philippines

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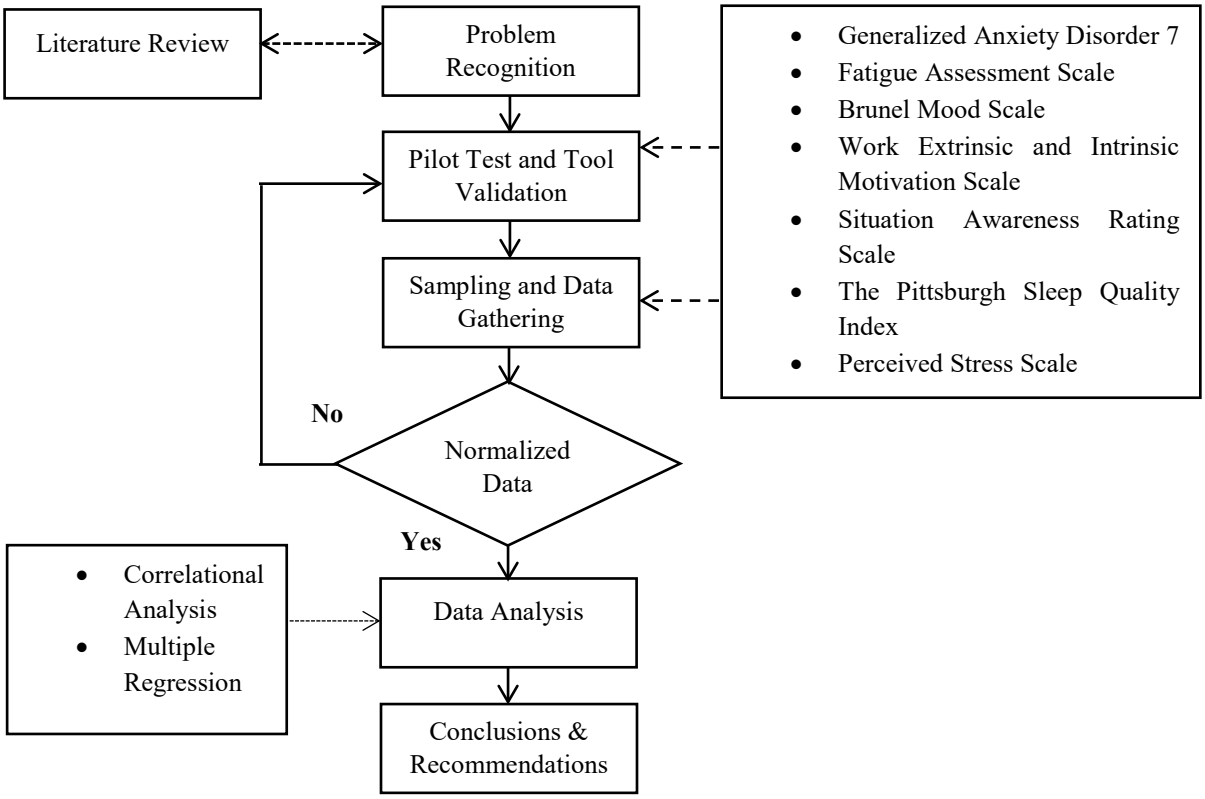

Figure 2. Data Collection Framework

4. Results and Discussion

The researchers conducted an Anderson-Darling normality test from the data gathered from the sample size to determine its validity for a bias-free data. As indicated by the result, the p-value obtained from this study is 0.399, which shows the sample data possesses normal distribution. Table 2 shows the summary of the normality test results obtained through the use of the Minitab 17 statistical software.

Table 2. Minitab Result – Normality Test (Tabulated)

Factor	Frequency	Mean	Std. Deviation	AD	P-Value
Attention Score	384	567.2	192.5	0.381	0.399

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The figure below presents the normality test graph obtained from the attention scores. The figure is a graphical presentation of the normality test results obtained through the Minitab 17 statistical software. Figure 3 shows that most of the data points fall on the normal line.

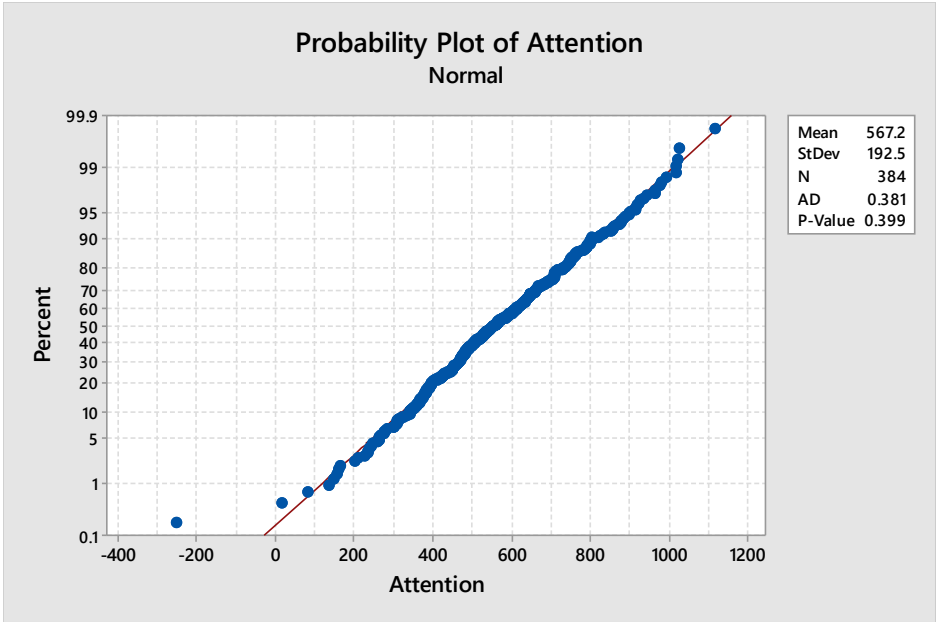

Figure 3. Normality Test Graph

The study considered the application of correlation analysis with the help of the Minitab 17 statistical software. Table 3 shows the correlation strengths between the factors considered in the study. The correlation strengths between the factors range from positively moderate to negatively strong. Age and gender, anxiety and mood, and fatigue and situation awareness resulted in positively moderate correlation, while fatigue and mood resulted in a negatively strong correlation. Together, these are the significant factors in terms of the relationship of the factors to one another.

Table 3. Minitab Result – Correlational Analysis

Factors			Correlation Coefficient	Strength
Age	<--------	Gender	0.308	Positively Moderate Correlation
Anxiety	<--------	Mood	0.321	Positively Moderate Correlation
Fatigue	<--------	Situation Awareness	0.356	Positively Moderate Correlation
Fatigue	<--------	Motivation	0.175	Positively Weak Correlation
Motivation	<--------	Situation Awareness	0.289	Positively Weak Correlation
Workload	<--------	Age	0.105	Positively Weak Correlation
Workload	<--------	Gender	0.147	Positively Weak Correlation
Fatigue	<--------	Mood	-0.555	Negatively Strong Correlation
Alcohol	<--------	Smoker/Non-smoker	-0.322	Negatively Moderate Correlation
Anxiety	<--------	Fatigue	-0.355	Negatively Moderate Correlation
Age	<--------	Smoker/Non-smoker	-0.152	Negatively Weak Correlation

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Alcohol	<--------	Age	-0.220	Negatively Weak Correlation
Alcohol	<--------	Gender	-0.273	Negatively Weak Correlation
Anxiety	<--------	Stress	-0.188	Negatively Weak Correlation
Anxiety	<--------	Gender	-0.154	Negatively Weak Correlation
Motivation	<--------	Mood	-0.228	Negatively Weak Correlation
Situation Awareness	<--------	Stress	-0.125	Negatively Weak Correlation
Situation Awareness	<--------	Mood	-0.288	Negatively Weak Correlation
Sleep	<--------	Stress	-0.126	Negatively Weak Correlation
Smoker/Non-smoker	<--------	Mood	-0.164	Negatively Weak Correlation

The tables below show the summary of the results of the multiple regression analysis performed through the use of the Minitab 17 software. Table 4 presents the model summary in which the values for S, R-squared, adjusted R-squared, and predicted R-squared can be seen, while Table 5 presents the coefficients for the regression equation together with the p-values and variance inflation factors obtained from the model. The results show that anxiety, motivation, and sleep have significant coefficients since their p-value is less than the alpha level 0.05. Anxiety, motivation, and sleep have VIFs of 1, 1.01, and 1, respectively. This indicates that the correlation coefficients are stable because of low multicollinearity. When it comes to the variance inflation factors, it always starts at 1, which indicates that there is no correlation between the independent variable and the other factors. VIFs between 1 and 5 are moderately correlated, and if the value exceeds 5, it represents a critical level of multicollinearity. High multicollinearity between factors results to an unstable model.

Table 4. Minitab Results – Multiple Regression Analysis (Model Summary)

S	R-squared	Adjusted R-squared	Predicted R-squared
102.517	27.80%	26.99%	25.70%

Table 5. Minitab Results – Multiple Regression Analysis (Coefficients, P-Values, and VIFs)

Term	Coefficient	P-Value	Variance Inflation Factor
Constant	530.6	0.000	
Anxiety	-3.68	0.035	1.00
Motivation	3.505	0.000	1.01
Sleep	12.33	0.000	1.00

Figure 4 presents the residuals versus fits plot obtained from the multiple regression analysis. The figure shows that the data points are scattered and have no pattern amongst them. This means that the assumption that the residuals are randomly distributed is true and the residuals have constant variance.

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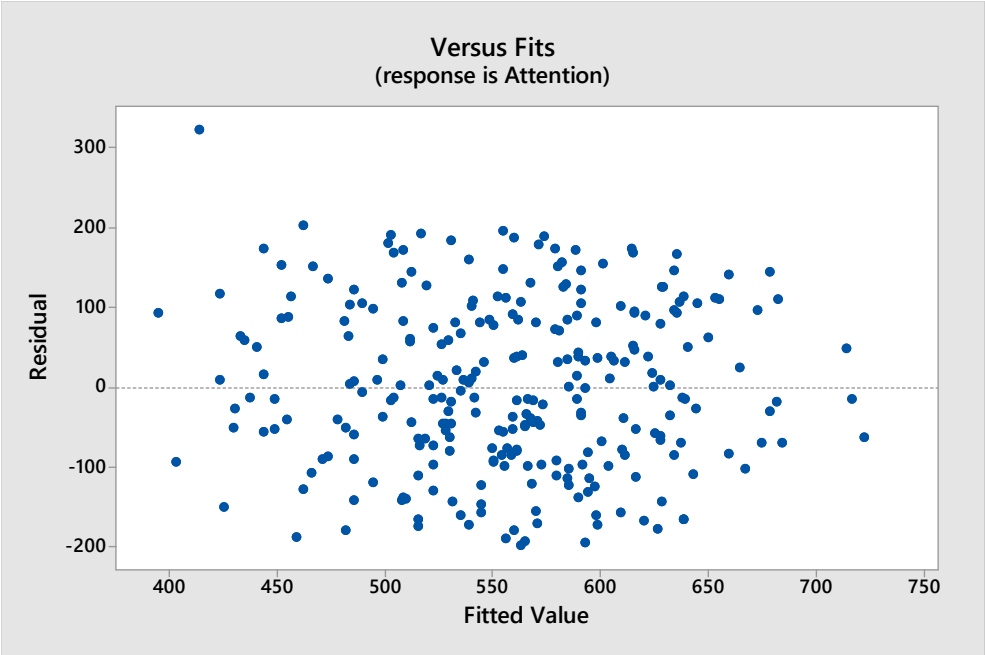

Figure 4. Residuals versus Fits Plot

The figure below presents the residuals versus order plot obtained from the multiple regression analysis. Figure 5 shows that the data points are scattered and do not follow a trend when displayed in time order. This means that the residuals are independent from one another and are not correlated.

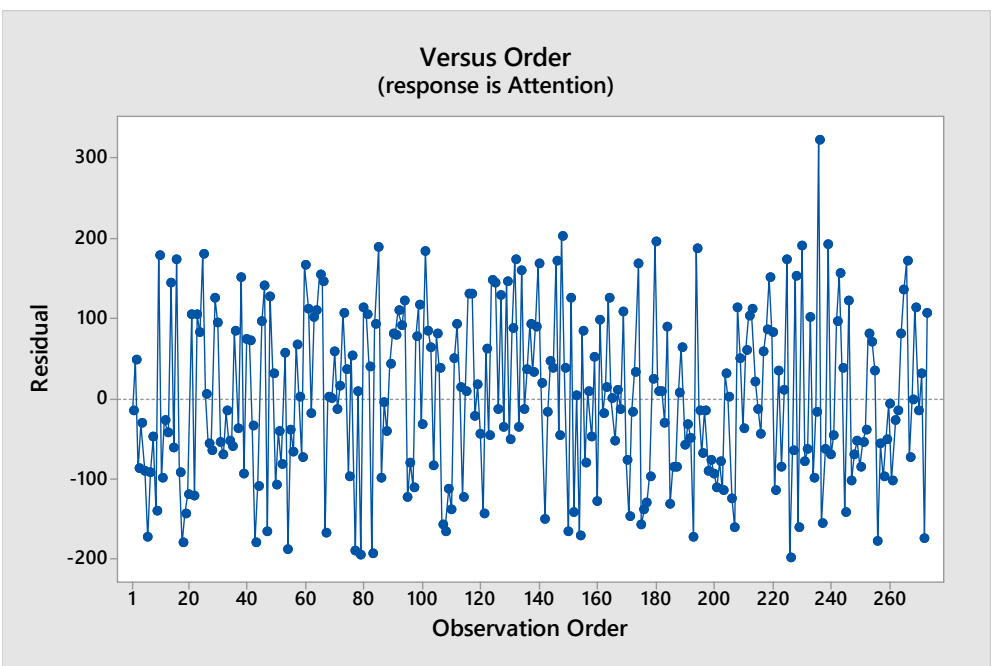

Figure 5. Residuals versus Order Plot

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The regression equation is the generated model after running multiple regression analysis. It shows the different ratios of different variables (i.e. anxiety, motivation, and sleep) to its corresponding response variable (i.e. attention). This is a predictive model of attention to determine the (attention score and unit) responding to the different data behavior of the given independent variables using the assessment used in this study. Using the Minitab 17 statistical software, the equation is shown below.

$$Y\ (Attention) = 530.6 - 3.68\ X1\ (Anxiety) + 3.505\ X3\ (Motivation) + 12.33\ X15\ (Sleep)$$

5. Conclusions

Based on the statistical tests applied by the researchers, the sample data is normal, having a p-value of 0.399, which is greater than the alpha level of 0.05. The multiple regression analysis results show that anxiety (p-value = 0.035), motivation (p-value = 0.000), and sleep (p-value = 0.000) are the factors that are statistically significant to driver attention. Moreover, the low r-squared value obtained does not indicate that the model produced by the multiple regression analysis is not a good fit for the data. It is normal for fields that study and aim to predict human behavior to obtain r-squared values less than 50% because of the differences between personalities in individuals.

This study led the researchers to conclude that the assessment of the factors significant to driver attention could be the starting point in improving driver stimuli recognition in order to reduce the risk of road accidents in the Philippines. Assessment of the different factors found to be statistically significant to driver attention is important because driving skill is not the sole predicting factor in identifying which drivers have a high probability of being involved in road accidents. In the Philippines where driving conditions are frustrating, to say the least, consideration of the factors included in this study contributes to ensuring safety in Philippine roads.

6. Recommendations

The following significant factors (1) sleep - attention, (2) motivation – attention, and (3) anxiety – attention needs to be addressed in order to increase the attention level and the driving performance. Moreover, the researchers are recommending the following:

Table 6. Summary of Recommendations

PRESENT	PROPOSED	PROBLEM/S ADDRESS
Driving at any period of the day.	If at all possible, avoid driving between midnight and 6 AM.	The driver will now respect the natural circadian rhythm of the human body that affects driving performance.
The average sleep of the respondents is 6 hours and 30 minutes.	• Get seven to eight (7-8) hours of sleep as much as possible before driving. • Create a sleeping habit including time of sleep, wake up time, and sleep duration	• Driver's lack of sleep. • Circadian rhythm of the driver
47% of the respondents are considered anxious moderately and 11% of them are anxious severely.	• Meditate before driving to reduce psychological stress (anxiety, positive mood, mental health-related quality of life, attention) • Exercise at least 30 minutes a day	The driver will now improve their attention by reducing anxiety.

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The average motivation scores of respondets is 10.26, which is 28% of the maximum score.	Drivers should educate themselves about the dangers on the road before or during the driving task.	Motivation is now increased for the driver as he/she is informed about the risks involved in performing the driving task.

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